Test Data: Effectiveness of Nycon*RC* Fibers as Reinforcement in Hardened Concrete

Overview

Testing was undertaken to determine the compliance of NyconRC fibers with ICC Engineering Services, Inc. (ES), acceptance criteria (AC) for concrete reinforced with synthetic fibers. A joint committee of ICC ES personnel and synthetic fiber industry representatives established acceptance criteria to evaluate the performance of synthetic fibers as temperature-shrinkage reinforcement in concrete, i.e., AC 32, Section 4.1.2. The test results demonstrated the effectiveness of NyconRC fibers as secondary temperature-shrinkage reinforcement in hardened concrete.

Material Description

0.75" (19mm) Multifilament Virgin Nylon Fiber

Standard Dosage Rate

1.0 pound/cubic yard (0.60 kg/cubic meter) of concrete

ICC Test Procedure	Plain Concrete	RC-Reinforced Concrete	% of Plain Concrete	ICC Specs
Compressive Strength	19.8 MPa (2,874 psi)	22.1 MPa (3,214 psi)	111.8%	≥ Plain Concrete
Flexural Strength	3.99 MPa (579 psi)	4.12 MPa (598 psi)	103.3%	≥ Plain Concrete
Splitting Tensile Strength	2.4 MPa (368 psi)	2.75 MPa (399 psi)	108.4%	
Bond Strength	3.34 MPa (485 psi)	3.90 MPa (565 lbs)	116.5%	≥ Plain Concrete
Bond Strength/ Unit Slip	19.2 MPa (2,785 ksi)	20.3 MPa (2,947 ksi)	105.8%	
Plastic Shrinkage Cracking		86.0% Reduction		Minimum Reduction 40%
Impact Resistance 28 Days	11 blows	22 blows	200%	≥ Plain Concrete

Compatibility with Concrete	8 Weeks	16 Weeks	32 Weeks	52 Weeks	
% Unaged I-10/I-5 Residual Strength	144	125	133	120	≥ Plain Concrete

Testing labs used: Stork Twin City Testing Corporation, St. Paul, Minnesota
Rutgers University, New Jersey
F & R Labs, Richmond, Virginia

Standard Test Methods Used In Program

Compressive Strength	ASTM C39
Flexural Strength	ASTM C78
Freeze/Thaw Durability	ASTM C666 Method A
Bond Strength	ASTM C234
Plastic Shrinkage	ICC ES AC 32 Appendix B
Impact Resistance	ICC ES AC 32 Appendix C-2
Compatibility with Concrete	ICC ES AC 32 Annex C-1

Specimens per Test Set

- Three test specimens were used per test set for compressive, flexural, bond strength, plastic shrinkage and compatibility with concrete.

Discussion of Performance Criteria

• Compressive, Flexural, and Bond Strength

These tests insure that the synthetic fibers do not compromise the performance of reinforced concrete when compared to plain concrete.

Test Results

Compression, flexural, and bond strength test results for the NyconRC specimens exceeded the performance of plain concrete. The data prove that NyconRC fibers enhance the soundness of the concrete matrix, and their three-dimensional distribution in the matrix provides for the distribution of load over a greater volume of concrete.

• Plastic Shrinkage

This test is required to show that NyconRC fibers do, in fact, provide a reduction in measurable crack formation and growth. A minimum reduction in measurable shrinkage of 40% is required when comparing NyconRC specimens to plain concrete specimens.

Test Results

The plastic shrinkage test results show a major reduction in measurable cracks of 57% when compared to the plain concrete, exceeding the 40% minimum reduction specified. The value of NyconRC's benefit can best be stated as a durability enhancement: If there are fewer cracks created during the plastic and initial hardening phases and the crack widths are less, then the concrete will be less permeable, improving fatigue strength.

- **Impact Resistance**

  This test is required to show that the synthetic fibers hold concrete together after it cracks, which is the sole performance requirement of temperature-shrinkage reinforcement. Again, a minimum "total failure" performance level is required. Total failure is defined as the number of blows that are required to have the fractured specimen touching three of the four lugs at the perimeter of the test area. For tests comparing number of blows to total failure when synthetic fiber specimens have been aged for seven days, the minimum improvement compared to plain concrete at the same age is 200%. When specimens are 28 days old, the improvement is 150%.

  Test Results
  NyconRC fibers exceeded 28-day requirement. Impact resistance data show the superior ability of NyconRC to bond with concrete, thus providing resistance to the cracked concrete's propensity to separate or push apart. Test results illustrate the ability of the fibers to hold concrete together after it cracks, insuring that the concrete will continue to perform as required. There are other benefits assignable to the three-dimensionally distributed NyconRC fibers, among the most prominent of which would be their suitability for reinforced concrete in seismic-resistant structures.

- **Compatibility with Concrete**

  This is an accelerated aging test used to show whether the synthetic fiber chemically reacts with the mortar matrix and/or loses strength. ASTM C1609 is the test method used to evaluate performance, specifically residual strength; this is a calculated number for the toughness index generated by the test results. Beams are tested at 8, 16, 32 and 52 weeks of accelerated aging. Data generated must be equal to or greater than 85% of the unaged data.

  Test Results
  The data for compatibility with concrete at all specimen ages shows NyconRC fibers exceeded the minimum required residual strength value of 85%. In fact, the residual strength of the 52-week-aged specimens was 120% of the unaged. These results, coupled with the program's other test results, demonstrate the superior bonding properties of NyconRC fibers.

Conclusions

The results of testing validate the benefits of NyconRC fibers in concrete and demonstrate that NyconRC-reinforced concrete meets or exceeds the performance criteria of ICC ES AC 32, Section 4.1.2, Synthetic Fibers as Temperature-Shrinkage Reinforcement in Concrete.

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